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(54) **AUTONOMOUS DRIVING VEHICLE AND DRIVERLESS TRANSPORTATION SYSTEM**

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(56) **References Cited**

U.S. PATENT DOCUMENTS

5,289,369 A 2/1994 Hirshberg
6,636,145 B1 10/2003 Murakami et al.
(Continued)

FOREIGN PATENT DOCUMENTS

JP 2016-115364 A 6/2016

OTHER PUBLICATIONS

Notice of Allowance issued Oct. 5, 2022 in U.S. Appl. No. 17/376,318.
(Continued)

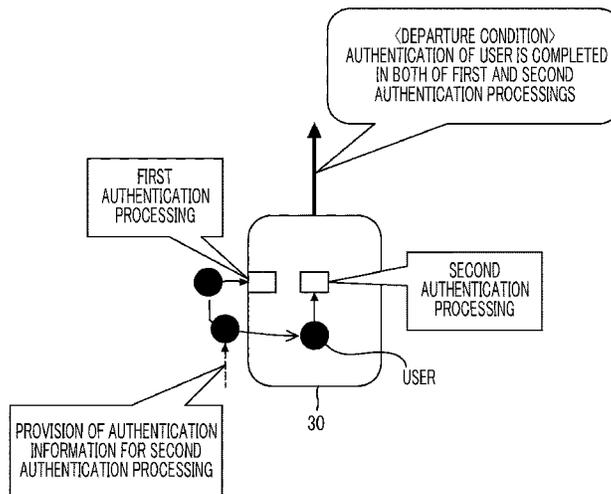
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(57) **ABSTRACT**

When an autonomous driving vehicle picks a user up, a control device performs departure condition confirmation processing. The departure condition confirmation processing includes first authentication processing that performs authentication of the user outside the autonomous driving vehicle based on first authentication information, door lock release processing that releases a door lock in response to the completion of the first authentication processing, second authentication information provision processing that makes the user acquire second authentication information different from the first authentication information in response to the completion of the first authentication processing, second authentication processing that performs authentication of the user inside a vehicle cabin of the autonomous driving vehicle based on the second authentication information, and start permission processing that permits the start of the autonomous driving vehicle in a case where the second authentication processing is completed.

14 Claims, 10 Drawing Sheets



Related U.S. Application Data

continuation of application No. 16/828,396, filed on Mar. 24, 2020, now Pat. No. 11,104,301, which is a continuation of application No. 16/055,513, filed on Aug. 6, 2018, now Pat. No. 10,647,297.

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(56)

References Cited

U.S. PATENT DOCUMENTS

6,873,840	B1	3/2005	von Alten	
8,732,803	B2	5/2014	Stibel et al.	
9,547,309	B2	1/2017	Ross et al.	
10,607,192	B2 *	3/2020	Abbas	G05D 1/0088
10,647,297	B2 *	5/2020	Watanabe	B60R 25/2036
10,749,960	B2 *	8/2020	Way	H04W 4/44
10,761,527	B2 *	9/2020	Way	G07C 5/008
10,820,148	B2 *	10/2020	Pao	H04W 4/021
10,953,852	B1 *	3/2021	Krishnamurthi	G05D 1/0276
11,104,301	B2	8/2021	Watanabe	
11,267,401	B2 *	3/2022	Krishnamurthi	B60Q 9/00
11,600,182	B2 *	3/2023	Fujii	A61B 5/14551
11,714,414	B2 *	8/2023	Matthiesen	G06Q 10/02701/25
11,796,998	B2 *	10/2023	Kentley-Klay	G05D 1/0291
2003/0033175	A1 *	2/2003	Ogura	G06Q 10/02705/5
2006/0049962	A1 *	3/2006	Okada	B60R 25/24340/901

2006/0082437	A1 *	4/2006	Yuhara	B60R 25/255340/5.82
2011/0060480	A1 *	3/2011	Mottla	G07C 9/00571701/2
2011/0112969	A1 *	5/2011	Zaid	H04W 4/027701/2
2012/0254948	A1	10/2012	Kleve et al.	
2013/0073114	A1 *	3/2013	Nemat-Nasser	B60R 25/25382/104
2015/0161832	A1	6/2015	Esselink et al.	
2015/0185034	A1 *	7/2015	Abhyanker	G05D 1/0088701/23
2015/0279131	A1	10/2015	Nespolo	
2016/0301698	A1	10/2016	Katar et al.	
2016/0344747	A1 *	11/2016	Link, II	H04W 4/021
2017/0008490	A1 *	1/2017	Sako	G07C 9/00571
2017/0115125	A1 *	4/2017	Outwater	H04W 4/40
2017/0251092	A1 *	8/2017	Elie	H04W 12/06
2017/0263062	A1 *	9/2017	Bergerhoff	B60R 25/04
2017/0278329	A1 *	9/2017	Konishi	G06K 7/10366
2018/0262891	A1	9/2018	Wu et al.	
2018/0292829	A1	10/2018	Li	
2018/0374002	A1	12/2018	Li	
2019/0054926	A1	2/2019	Wasekura	
2019/0061688	A1	2/2019	Watanabe	
2020/0282953	A1	9/2020	Watanabe	
2021/0339705	A1	11/2021	Watanabe	

OTHER PUBLICATIONS

Office Action Jun. 21, 2022 issued in U.S. Appl. No. 17/376,318.
 U.S. Appl. No. 16/055,513, filed Aug. 6, 2018.
 U.S. Appl. No. 16/828,396, filed Mar. 24, 2020.
 United States Office Action dated Nov. 24, 2023 in U.S. Appl. No. 18/147,451.
 Notice of Allowance dated May 13, 2024, issued in U.S. Appl. No. 18/147,451.

* cited by examiner

FIG. 1

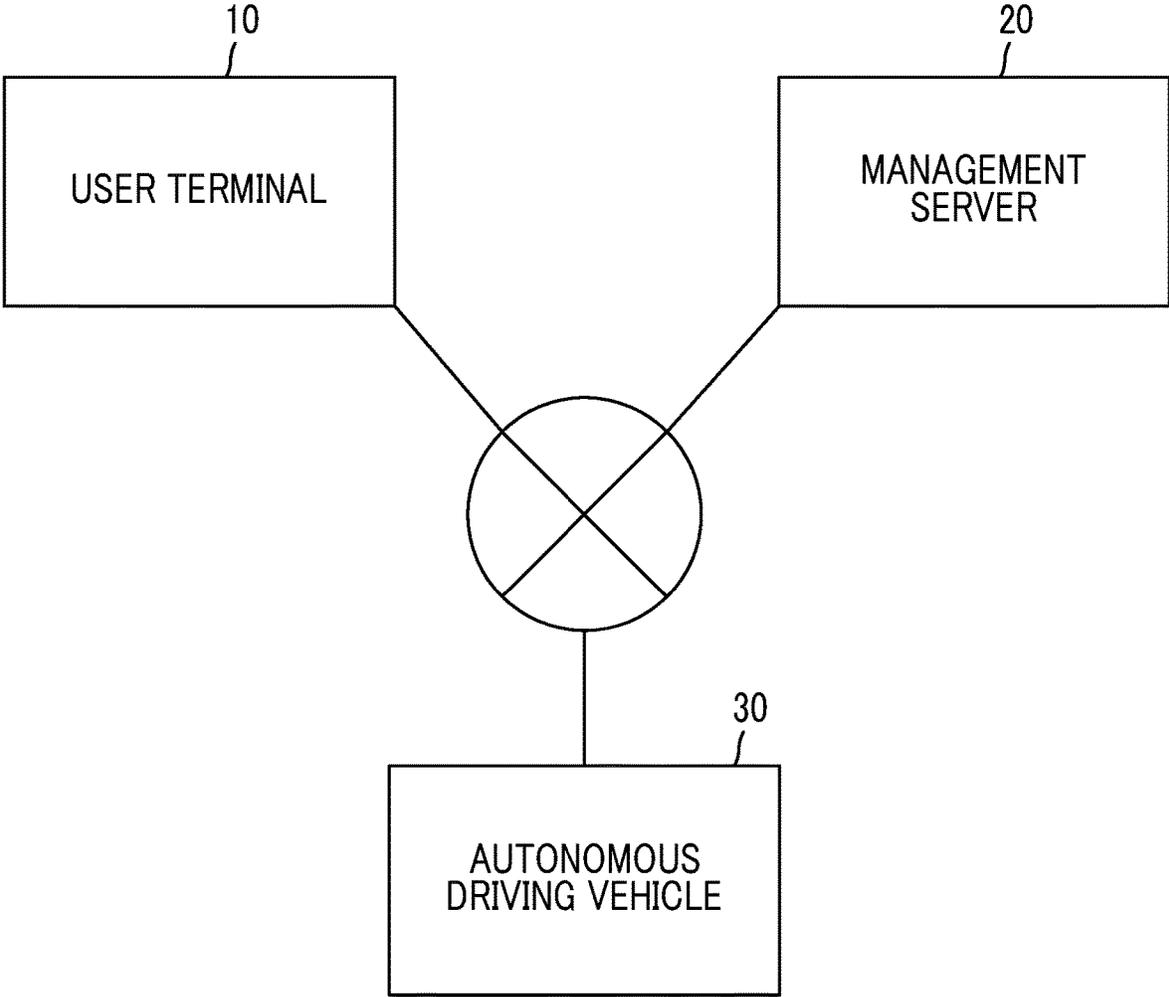


FIG. 2

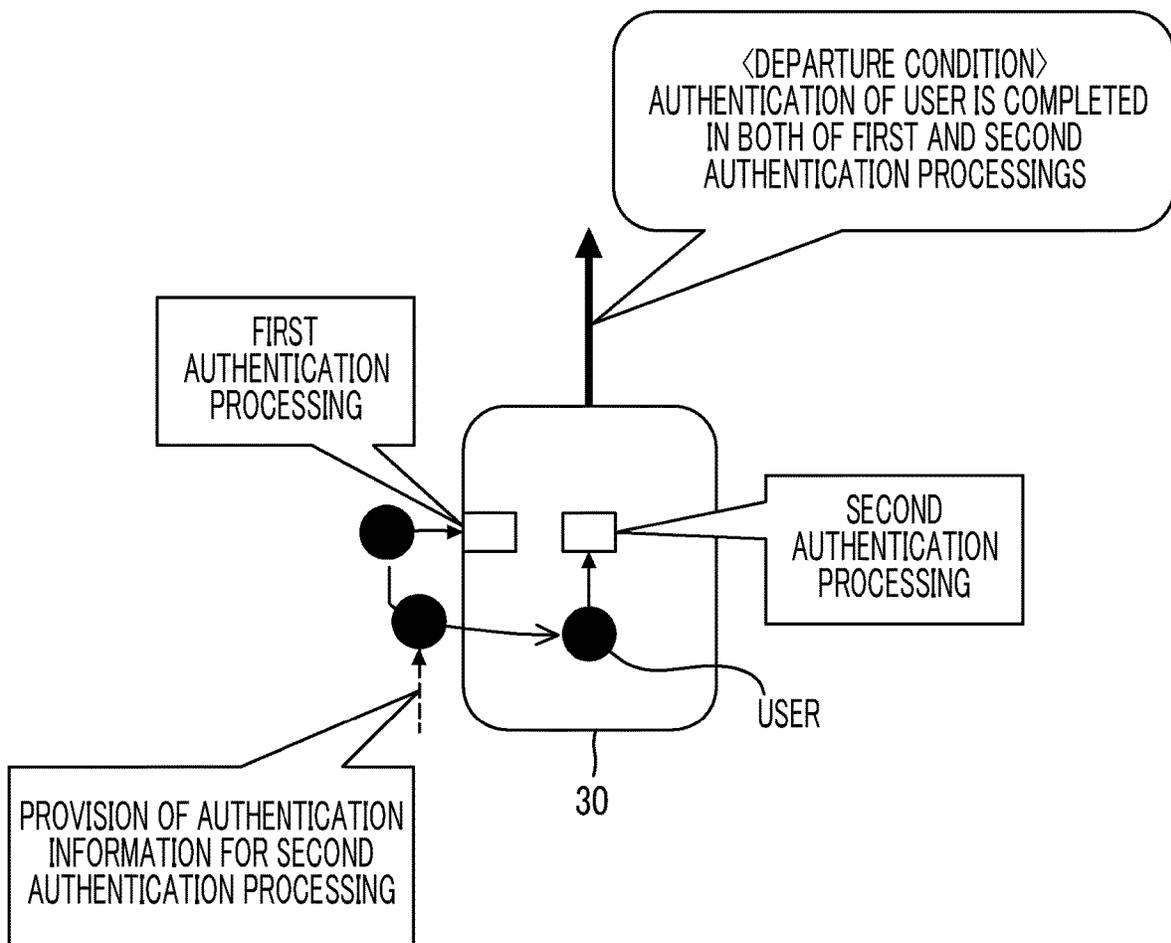


FIG. 3

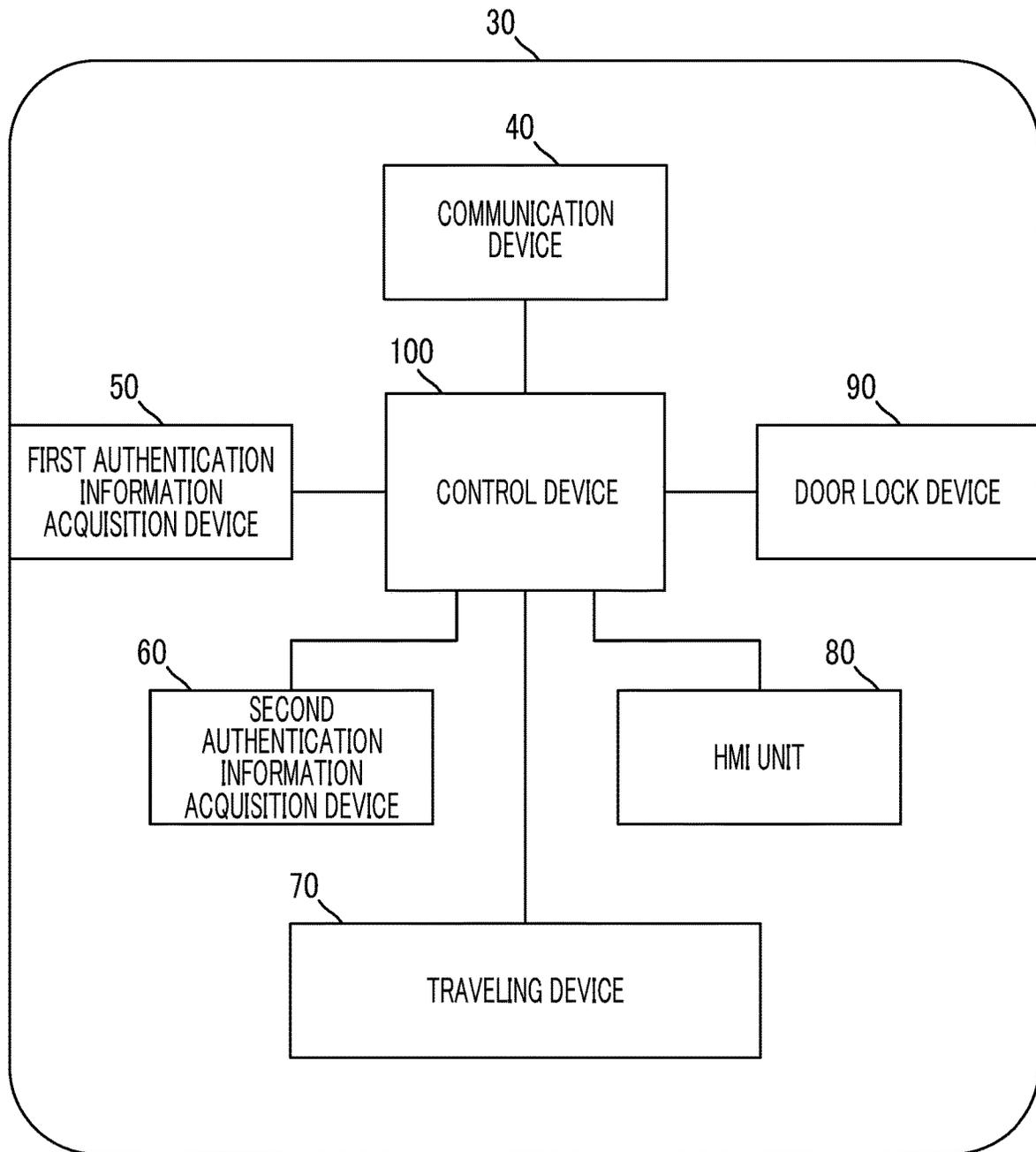


FIG. 4

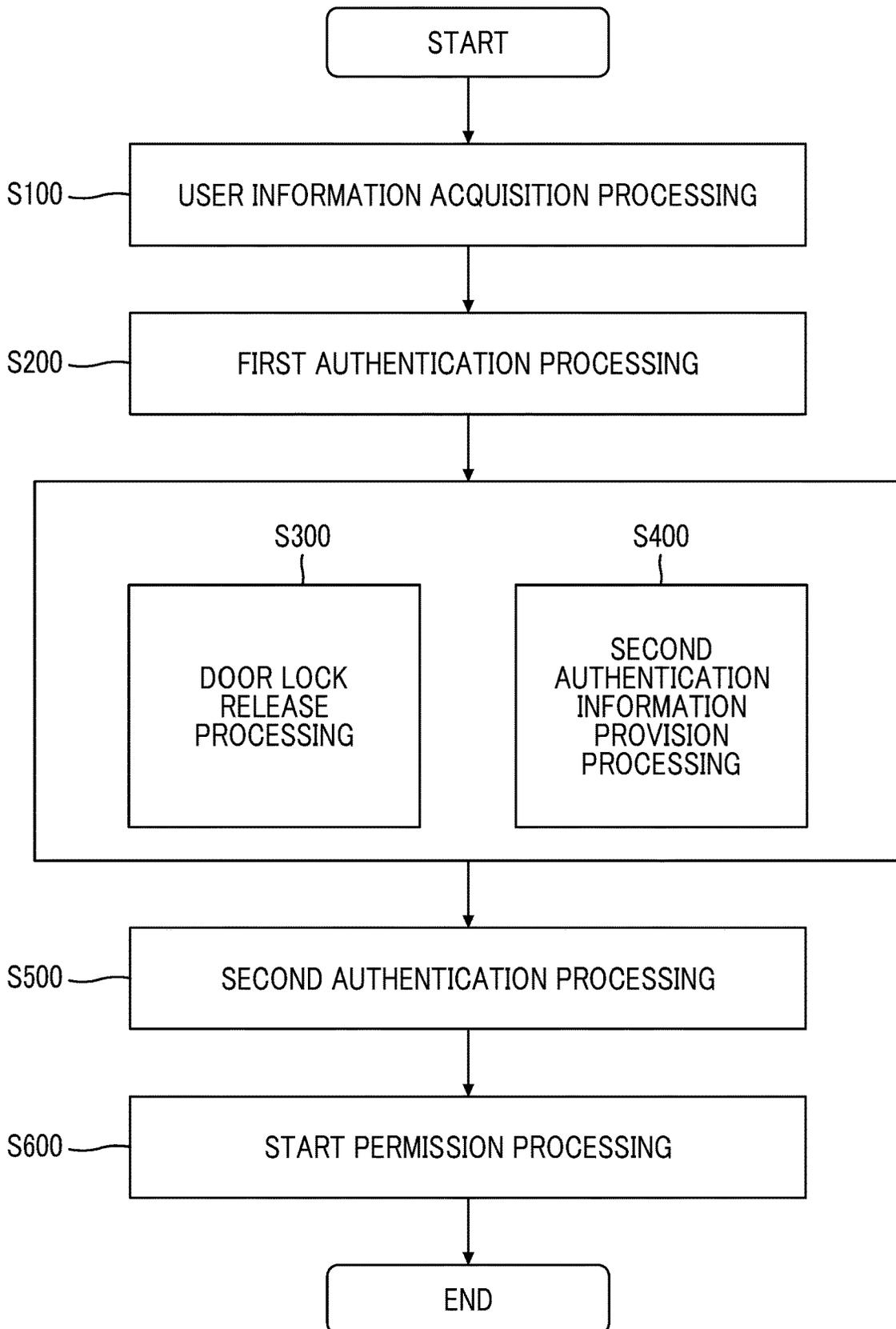


FIG. 5

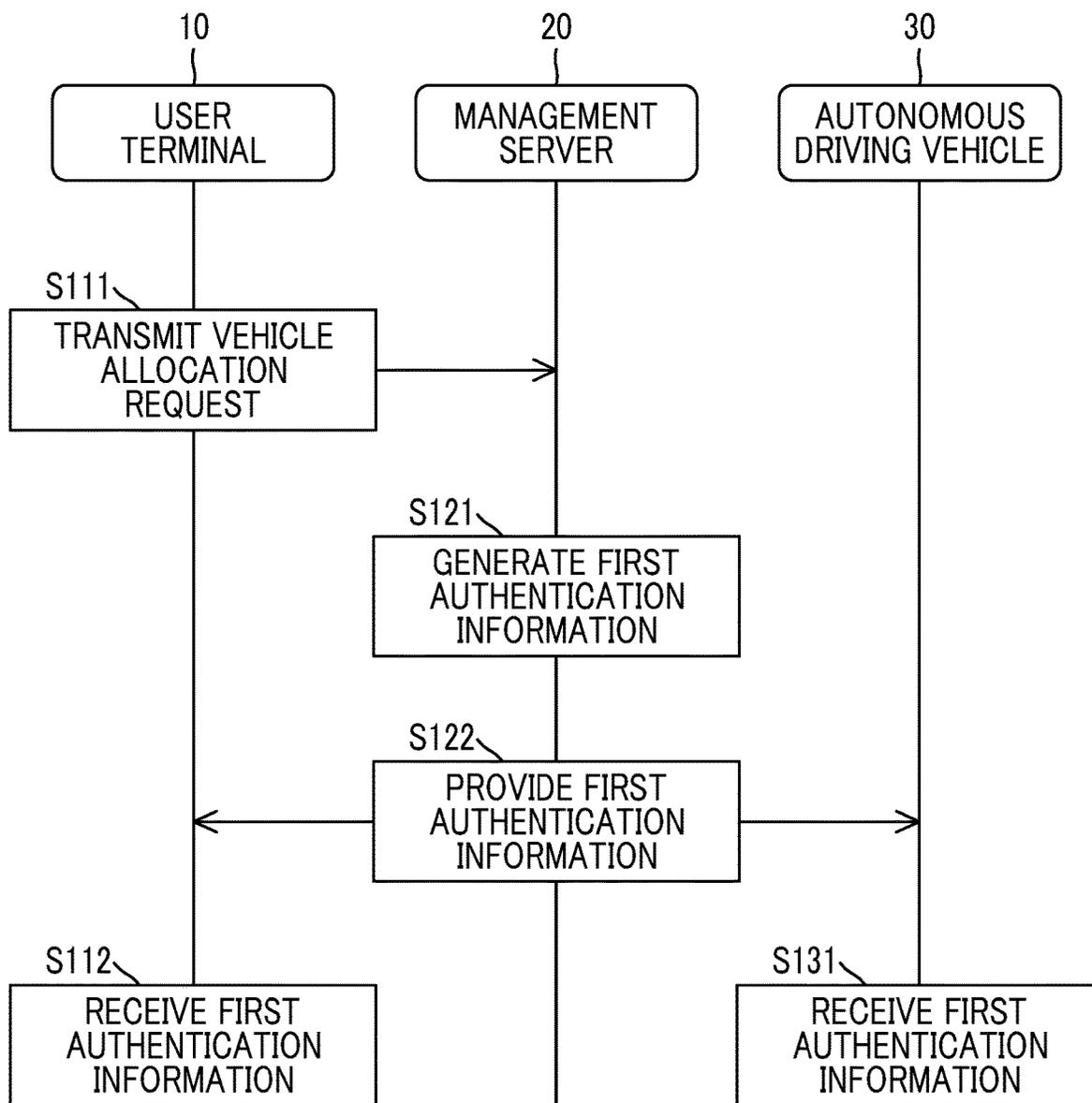


FIG. 6

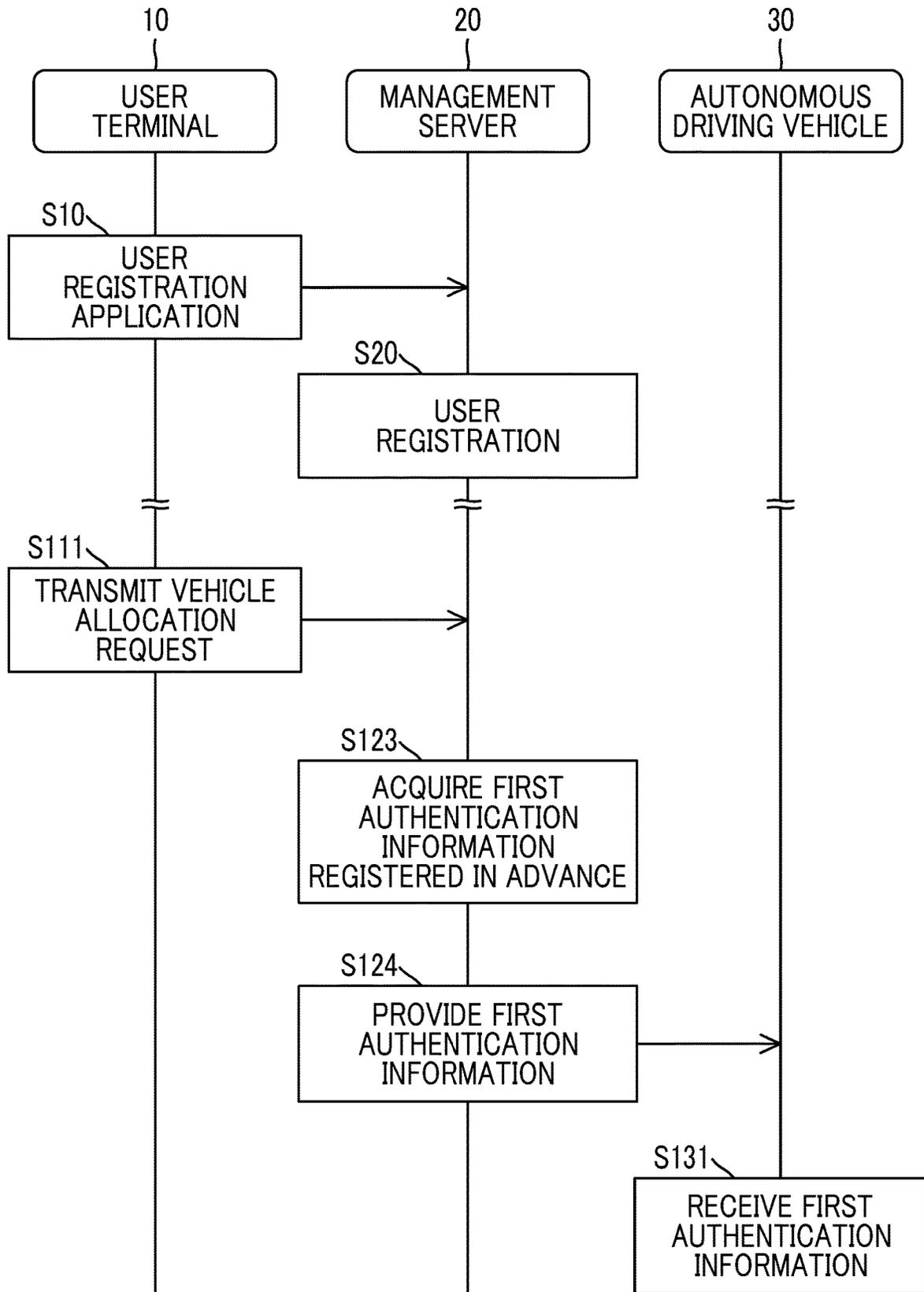


FIG. 7

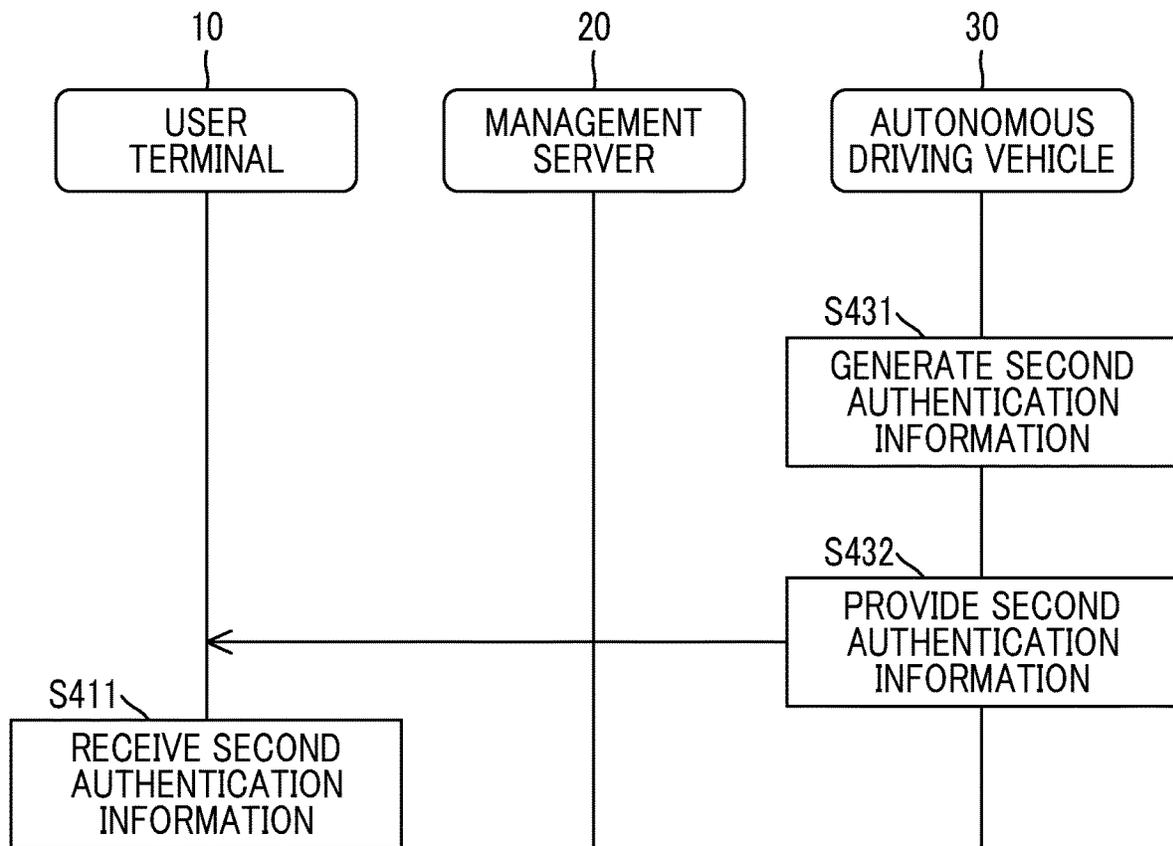


FIG. 8

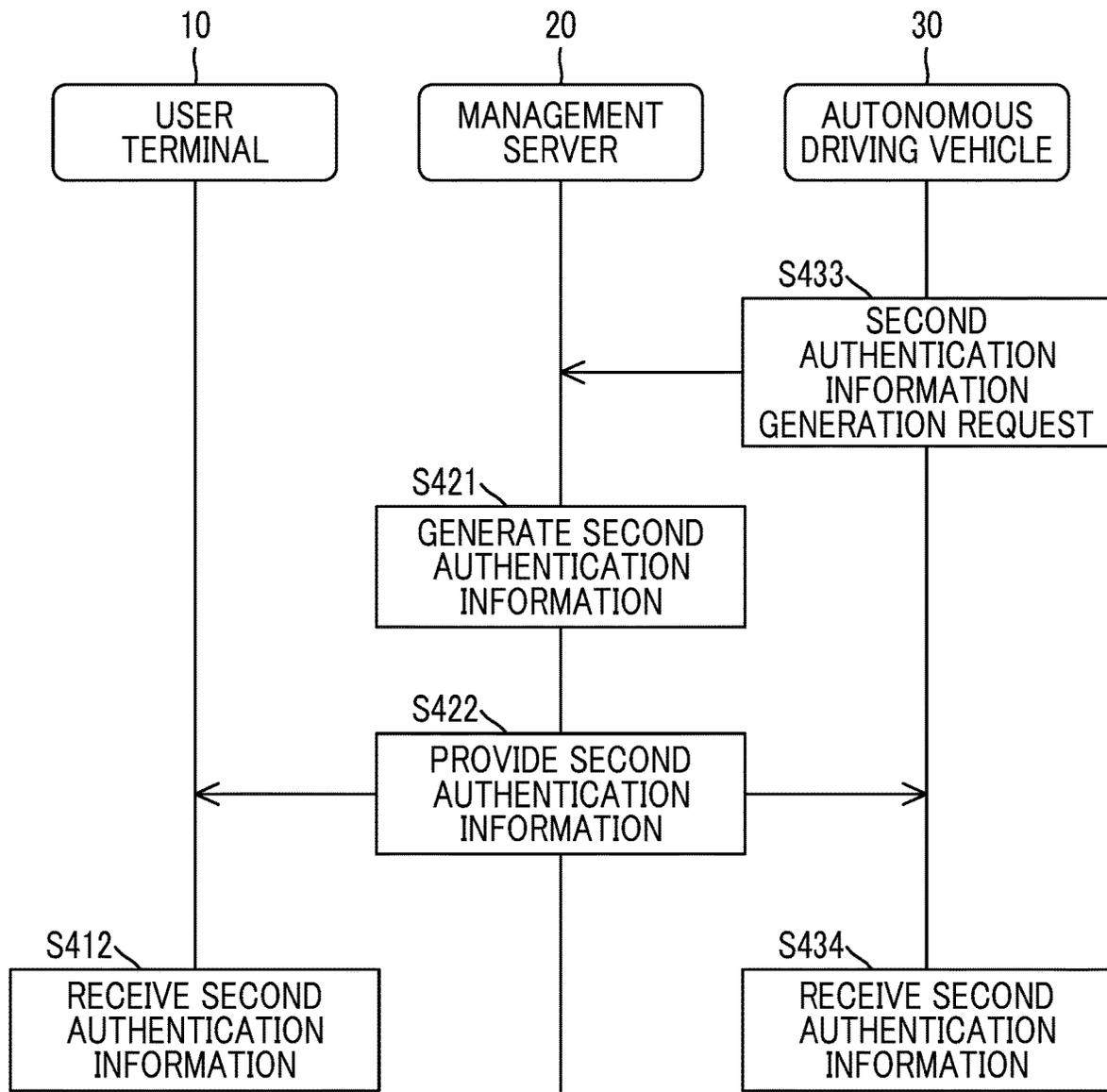


FIG. 9

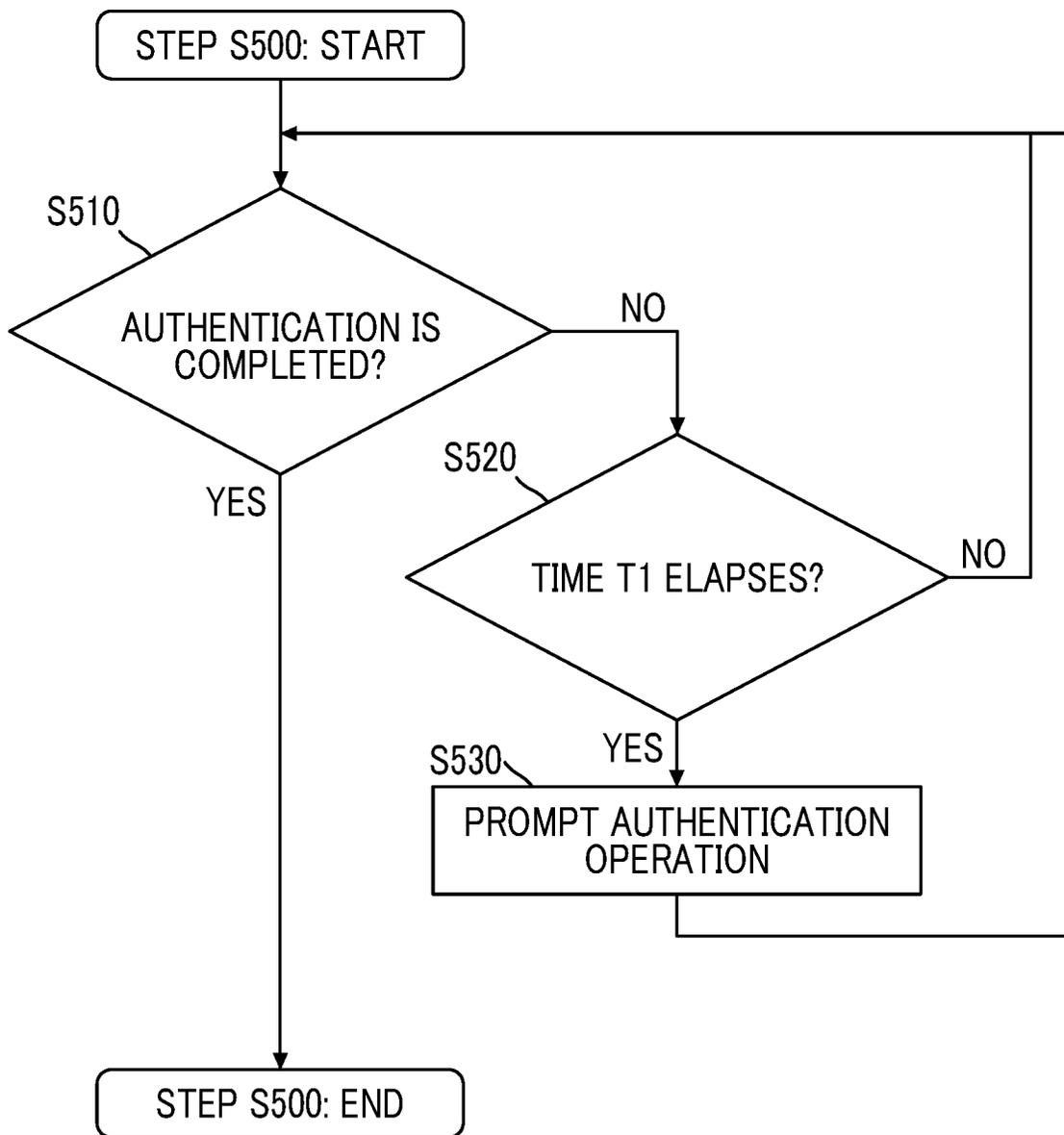
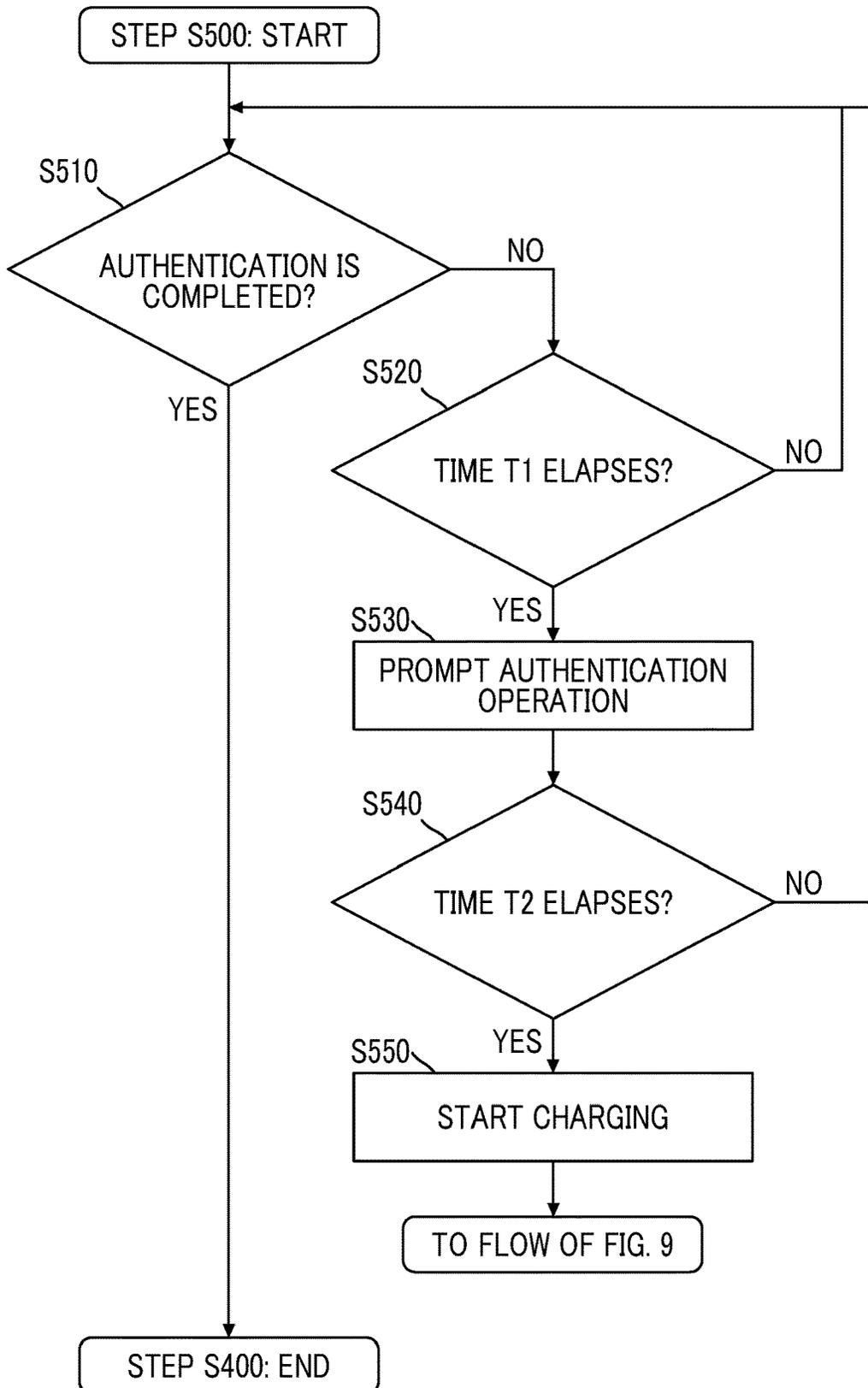


FIG. 10



**AUTONOMOUS DRIVING VEHICLE AND
DRIVERLESS TRANSPORTATION SYSTEM**

INCORPORATION BY REFERENCE

This is a Continuation Application of U.S. patent application Ser. No. 17/376,318, filed Jul. 15, 2021 in the U.S. Patent and Trademark Office, which application is a Continuation Application of U.S. patent application Ser. No. 16/828,396, filed Mar. 24, 2020, now U.S. Pat. No. 11,104,301, issued Aug. 31, 2021, which is a Continuation Application of U.S. application Ser. No. 16/055,513, filed Aug. 6, 2018, now U.S. Pat. No. 10,647,297, issued May 12, 2020, which claims priority from Japanese Patent Application No. 2017-162634 filed on Aug. 25, 2017. The specifications, drawings and abstracts of the prior applications are incorporated herein by reference in their entireties.

BACKGROUND

1. Technical Field

The present disclosure relates to an autonomous driving vehicle and a driverless transportation system that provide a driverless transportation service.

2. Description of Related Art

U.S. Pat. No. 9,547,309 discloses a transport arrangement system. In the transport arrangement system, in a case where a transport request is received from a user, the type of vehicle arranged for the user is determined. For example, the transport arrangement system determines whether or not to arrange an autonomous driving vehicle taking into consideration a destination designated by the transport request.

Japanese Unexamined Patent Application Publication No. 2016-115364 (JP 2016-115364 A) discloses a vehicle allocation management system using an autonomous driving vehicle. In a case where a user performs member registration, a vehicle allocation management server stores first information for authentication and second information for authentication relating to the user. In a case where a vehicle allocation request is received from the user, the vehicle allocation management server transmits the first information for authentication to the autonomous driving vehicle. The autonomous driving vehicle performs the authentication of the user using the first information for authentication. The autonomous driving vehicle receives the second information for authentication from the user, and transmits the received second information for authentication to the vehicle allocation management server. The vehicle allocation management server performs the authentication of the user using the second information for authentication, and notifies the autonomous driving vehicle of an authentication result.

US 2016/0301698 A discloses an in-vehicle authentication system of an autonomous driving vehicle. The in-vehicle authentication system determines ID information and the age of the user, the number of people, and the like as an authentication policy, and performs the authentication of the user based on the authentication policy.

US 2017/0115125 A discloses an authentication method of a user in a vehicle allocation service. A management system generates a code peculiar for a position where a vehicle picks the user up. One of the vehicle and a user terminal emits a light signal based on the code, and the other of the vehicle and the user terminal detects the light signal using a camera.

U.S. Pat. No. 8,732,803 discloses a general two-stage authentication method unrelated to a vehicle allocation service of an autonomous driving vehicle.

SUMMARY

A driverless transportation service using an unmanned autonomous driving vehicle is considered. In the driverless transportation service, the autonomous driving vehicle needs to automatically pick a user up. Specifically, the autonomous driving vehicle goes toward a pickup position desired by the user. At the pickup position desired by the user, the user gets in the autonomous driving vehicle. The autonomous driving vehicle departs toward a destination.

When the autonomous driving vehicle picks the user up, the following problem may occur. For example, in a state where the user does not get in the autonomous driving vehicle, the autonomous driving vehicle may start. Since the autonomous driving vehicle can be in an unmanned operation, the autonomous driving vehicle may start without regard to an intention of the user or circumstances.

The disclosure provides a technique capable of restraining start of an autonomous driving vehicle in a state in which a user does not get in the autonomous driving vehicle in a driverless transportation service.

A first aspect of the disclosure relates to an autonomous driving vehicle that provides a driverless transportation service to a user. The autonomous driving vehicle includes a first authentication information acquisition device, a second authentication information acquisition device, and a control device. The first authentication information acquisition device is configured to acquire first authentication information associated with the user from the user outside the autonomous driving vehicle. The second authentication information acquisition device is configured to acquire second authentication information from the user inside a vehicle cabin of the autonomous driving vehicle. The control device is configured to control the autonomous driving vehicle. When the autonomous driving vehicle picks the user up, the control device performs departure condition confirmation processing. The departure condition confirmation processing includes first authentication processing that performs authentication of the user outside the autonomous driving vehicle based on the first authentication information acquired by the first authentication information acquisition device, door lock release processing that releases a door lock of the autonomous driving vehicle in response to the completion of the first authentication processing, second authentication information provision processing that makes the user acquire the second authentication information different from the first authentication information in response to the completion of the first authentication processing, second authentication processing that performs authentication of the user inside the vehicle cabin of the autonomous driving vehicle based on the second authentication information acquired by the second authentication information acquisition device, and start permission processing that permits the start of the autonomous driving vehicle in a case where the second authentication processing is completed.

In the autonomous driving vehicle according to the first aspect of the disclosure, in the second authentication information provision processing, the control device may generate the second authentication information and may provide the generated second authentication information to a terminal of the user.

In the autonomous driving vehicle according to the first aspect of the disclosure, in the second authentication infor-

mation provision processing, the control device may request a management server to generate and provide the second authentication information and may receive the second authentication information generated by the management server from the management server. The second authentication information generated by the management server may be provided from the management server to a terminal of the user.

In the autonomous driving vehicle according to the first aspect of the disclosure, after the completion of the first authentication processing, in a case where the second authentication processing is not completed even when a first predetermined time elapses, the control device may prompt the user to perform an authentication operation for the second authentication processing.

In the autonomous driving vehicle according to the first aspect of the disclosure, after the completion of the first authentication processing, in a case where the second authentication processing is not completed even when a second predetermined time longer than the first predetermined time elapses, the control device may start charging to the user authenticated by the first authentication processing.

A second aspect of the disclosure relates to a driverless transportation system that provides a driverless transportation service to a user. The driverless transportation system includes a management server and an autonomous driving vehicle. The autonomous driving vehicle is configured to be able to communicate with the management server. The autonomous driving vehicle includes a first authentication information acquisition device and a second authentication information acquisition device. The first authentication information acquisition device is configured to acquire first authentication information associated with the user from the user outside the autonomous driving vehicle. The second authentication information acquisition device is configured to acquire second authentication information from the user inside a vehicle cabin of the autonomous driving vehicle. When the autonomous driving vehicle picks the user up, the autonomous driving vehicle performs departure condition confirmation processing. The departure condition confirmation processing includes first authentication processing that performs authentication of the user outside the autonomous driving vehicle based on the first authentication information acquired by the first authentication information acquisition device, door lock release processing that releases a door lock of the autonomous driving vehicle in response to the completion of the first authentication processing, second authentication information provision processing that makes the user acquire the second authentication information different from the first authentication information in response to the completion of the first authentication processing, second authentication processing that performs authentication of the user inside the vehicle cabin of the autonomous driving vehicle based on the second authentication information acquired by the second authentication information acquisition device, and start permission processing that permits the start of the autonomous driving vehicle in a case where the second authentication processing is completed.

In the driverless transportation system according to the second aspect of the disclosure, in the second authentication information provision processing, the autonomous driving vehicle may generate the second authentication information and may provide the generated second authentication information to a terminal of the user.

In the driverless transportation system according to the second aspect of the disclosure, in the second authentication information provision processing, the autonomous driving

vehicle may request the management server to generate and provide the second authentication information. The management server may generate the second authentication information and may provide the generated second authentication information to the autonomous driving vehicle and a terminal of the user.

In the driverless transportation system according to the second aspect of the disclosure, the management server may generate the first authentication information and may provide the generated first authentication information to the autonomous driving vehicle and a terminal of the user in response to a vehicle allocation request from the user.

In the driverless transportation system according to the second aspect of the disclosure, the first authentication information may be registration information of the user that is registered in the management server in advance. The management server may provide the registration information as the first authentication information to the autonomous driving vehicle in response to a vehicle allocation request from the user.

According to the aspects of the disclosure, in the departure condition confirmation processing, the two-stage authentication processing is performed. Specifically, the first authentication processing is performed to the user outside the autonomous driving vehicle before the release of the door lock. After the completion of the first authentication processing, the second authentication information different from the first authentication information is provided to the user, and the second authentication processing is performed to the user inside the vehicle cabin of the autonomous driving vehicle. In a case where the second authentication processing is completed, the start of the autonomous driving vehicle is permitted.

With the first authentication processing before the release of the door lock, another person other than the user who transmits the vehicle allocation request is restrained from getting in the autonomous driving vehicle arrived at the pickup position without permission. With the second authentication processing, the autonomous driving vehicle is restrained from starting in a state in which the user does not get in the autonomous driving vehicle.

With the two-stage authentication processing, the following effect is also obtained. For example, a case where another person who is malicious acquires the first authentication information relating to the user in an unauthorized manner with means, such as hacking, is considered. According to the aspects of the disclosure, after the completion of the first authentication processing, the second authentication information different from the first authentication information is provided to the authorized user, and the second authentication processing is performed based on the second authentication information. Accordingly, even though another person can acquire the first authentication information, another person cannot pass the second authentication processing. That is, it is not possible for another person to start the autonomous driving vehicle.

As described above, according to the aspects of the disclosure, it is possible to restrain the start of the autonomous driving vehicle in a state in which the user who transmits the vehicle allocation request does not get in the autonomous driving vehicle. That is, it is possible to restrain the start of the autonomous driving vehicle unintended by the user.

BRIEF DESCRIPTION OF THE DRAWINGS

Features, advantages, and technical and industrial significance of exemplary embodiments of the disclosure will be

described below with reference to the accompanying drawings, in which like numerals denote like elements, and wherein:

FIG. 1 is a block diagram schematically showing the configuration of a driverless transportation system according to a first embodiment of the disclosure;

FIG. 2 is a conceptual diagram illustrating departure condition confirmation processing in an autonomous driving vehicle according to the first embodiment of the disclosure;

FIG. 3 is a block diagram showing a configuration example of the autonomous driving vehicle according to the first embodiment of the disclosure;

FIG. 4 is a flowchart showing the departure condition confirmation processing in the autonomous driving vehicle according to the first embodiment of the disclosure;

FIG. 5 is a conceptual diagram showing an example of a distribution method of first authentication information in a management server according to the first embodiment of the disclosure;

FIG. 6 is a conceptual diagram showing another example of the distribution method of the first authentication information in the management server according to the first embodiment of the disclosure;

FIG. 7 is a conceptual diagram showing an example of second authentication information provision processing according to the first embodiment of the disclosure;

FIG. 8 is a conceptual diagram showing another example of the second authentication information provision processing according to the first embodiment of the disclosure;

FIG. 9 is a flowchart showing second authentication processing according to a second embodiment of the disclosure; and

FIG. 10 is a flowchart showing second authentication processing according to a third embodiment of the disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

An embodiment of the disclosure will be described referring to the accompanying drawings.

1. First Embodiment

1-1. Driverless Transportation System

FIG. 1 is a block diagram schematically showing the configuration of a driverless transportation system **1** according to a first embodiment of the disclosure. The driverless transportation system **1** provides a driverless transportation service to a user. The driverless transportation system **1** includes a user terminal **10**, a management server **20**, and an autonomous driving vehicle **30**.

The user terminal **10** is a terminal that is carried with the user of the driverless transportation service. The user terminal **10** includes at least a processor, a storage device, and a communication device, and can perform various kinds of information processing and communication processing. For example, the user terminal **10** can communicate with the management server **20** and the autonomous driving vehicle **30** through a communication network. As the user terminal **10**, a smartphone is illustrated.

The management server **20** is a server that manages the driverless transportation service. The management server **20** includes at least a processor, a storage device, and a communication device, and can perform various kinds of information processing and communication processing. For example, the management server **20** can communicate with

the user terminal **10** and the autonomous driving vehicle **30** through the communication network. The management server **20** manages information of the user. The management server **20** manages vehicle allocation or the like of the autonomous driving vehicle **30**.

The autonomous driving vehicle **30** can be in an unmanned operation. The user gets in the autonomous driving vehicle **30**, and the autonomous driving vehicle **30** provides the driverless transportation service to the user. The autonomous driving vehicle **30** can communicate with the user terminal **10** and the management server **20** through the communication network.

A basic flow of the driverless transportation service is as follows.

The user transmits a vehicle allocation request using the user terminal **10**. The vehicle allocation request includes a pickup position desired by the user, or the like. The vehicle allocation request is sent to the management server **20** through the communication network. The management server **20** selects the autonomous driving vehicle **30** that provides the service to the user and sends information of the vehicle allocation request to the selected autonomous driving vehicle **30**. The autonomous driving vehicle **30** that receives information of the vehicle allocation request automatically goes toward the pickup position desired by the user.

The autonomous driving vehicle **30** arrives at the pickup position desired by the user and is stopped. The user gets in the autonomous driving vehicle **30**. The user sends a destination to the autonomous driving vehicle **30**. Alternatively, information of the destination may be included in the vehicle allocation request. The autonomous driving vehicle **30** automatically travels toward the destination. The autonomous driving vehicle **30** arrives at the destination and is stopped. The user gets off the autonomous driving vehicle **30**.

1-2. Outline of Departure Condition Confirmation Processing

When the autonomous driving vehicle **30** picks the user up in the driverless transportation service, the following problem may occur. For example, the autonomous driving vehicle **30** may start without permission while the user is loading a cargo in a trunk of the autonomous driving vehicle **30**. As another example, another person other than the user who transmits the vehicle allocation request may get in the autonomous driving vehicle **30** arrived at the pickup position without permission and may start the autonomous driving vehicle **30**.

As described above, in a state in which the user does not get in the autonomous driving vehicle **30**, the autonomous driving vehicle **30** may start. Since the autonomous driving vehicle **30** can be in an unmanned operation, the autonomous driving vehicle **30** may start without regard to an intention of the user or circumstances. The user feels a sense of discomfort or inconvenience with the unintended start described above. This causes degradation of reliability to the autonomous driving vehicle **30** and the driverless transportation service.

According to the first embodiment of the disclosure, a "departure condition" for permitting the start of the autonomous driving vehicle **30** at the pickup position desired by the user is specified. Determination is made whether or not the departure condition is satisfied before the autonomous driving vehicle **30** departs from the pickup position desired by the user toward the destination. The start of the autonomous driving vehicle **30** is prohibited until the departure condition

is satisfied. In a case where the departure condition is satisfied, the start of the autonomous driving vehicle 30 is permitted. The processing is hereinafter referred to as “departure condition confirmation processing”.

FIG. 2 is a conceptual diagram illustrating the departure condition confirmation processing in the autonomous driving vehicle 30 according to the first embodiment of the disclosure. According to the first embodiment of the disclosure, the departure condition confirmation processing includes two-stage authentication processing.

The two-stage authentication processing is “first authentication processing” for performing authentication of the user outside the autonomous driving vehicle 30 and “second authentication processing” for performing authentication of the user inside a vehicle cabin of the autonomous driving vehicle 30.

In more detail, in a case where the autonomous driving vehicle 30 arrives at the pickup position desired by the user, the autonomous driving vehicle 30 performs the first authentication processing to the user outside the autonomous driving vehicle 30. At this time, a door of the autonomous driving vehicle 30 is yet locked. In a case where the first authentication processing is completed, the autonomous driving vehicle 30 releases a door lock. In a case where the door lock is released, the user gets in the autonomous driving vehicle 30.

Authentication information for use in the second authentication processing is provided to the user terminal 10 transmitting the vehicle allocation request in response to the completion of the first authentication processing. A provision source of the authentication information may be the autonomous driving vehicle 30 or may be the management server 20. The user gets in the autonomous driving vehicle 30 and notifies the autonomous driving vehicle 30 of the authentication information received by the user terminal 10. The autonomous driving vehicle 30 performs the second authentication processing to the user inside the vehicle cabin of the autonomous driving vehicle 30 based on the authentication information. In a case where the second authentication processing is completed, the start of the autonomous driving vehicle 30 is permitted.

As described above, the departure condition in the first embodiment of the disclosure is that authentication of the user is completed in both of the first authentication processing and the second authentication processing. With the first authentication processing before the release of the door lock, another person other than the user who transmits the vehicle allocation request is restrained from getting in the autonomous driving vehicle 30 arrived at the pickup position without permission. With the second authentication processing, the autonomous driving vehicle 30 is restrained from starting in a state in which the user does not get in the autonomous driving vehicle 30.

Hereinafter, the configuration of the autonomous driving vehicle 30 and the departure condition confirmation processing according to the first embodiment of the disclosure will be described in detail.

1-3. Configuration Example of Autonomous Driving Vehicle

FIG. 3 is a block diagram showing a configuration example of the autonomous driving vehicle 30 according to the first embodiment of the disclosure. The autonomous driving vehicle 30 includes a communication device 40, a first authentication information acquisition device 50, a second authentication information acquisition device 60, a

traveling device 70, a human machine interface (HMI) unit 80, a door lock device 90, and a control device 100.

The communication device 40 performs communication with the outside of the autonomous driving vehicle 30. Specifically, the communication device 40 performs communication with the user terminal 10 through the communication network. The communication device 40 performs communication with the management server 20 through the communication network.

The first authentication information acquisition device 50 acquires authentication information for use in the first authentication processing from the user outside the autonomous driving vehicle 30. The authentication information for use in the first authentication processing is hereinafter referred to as “first authentication information”. The first authentication information is associated with the user who transmits the vehicle allocation request.

For example, the first authentication information is provided to the user in a format of a quick response (QR) code (Registered Trademark). In this case, the first authentication information acquisition device 50 has a QR code reader that reads the QR code. The user displays the QR code indicating the first authentication information on a display unit of the user terminal 10 and puts the display unit over the QR code reader. The first authentication information acquisition device 50 can acquire the first authentication information by reading the QR code.

As another example, the first authentication information may be a personal identification number (PIN) code. In this case, the first authentication information acquisition device 50 has a communication device that performs communication with the user terminal 10. The user transmits the PIN code using the user terminal 10 and requests for authentication. The first authentication information acquisition device 50 receives the first authentication information (PIN code) sent from the user terminal 10.

As still another example, the first authentication information may be biological information of the user. In this case, the first authentication information acquisition device 50 has a biological information reader that reads the biological information of the user. For example, a case where a “fingerprint” is used as the biological information of the user is considered. In this case, the first authentication information acquisition device 50 has a fingerprint reader. The user puts a finger over the fingerprint reader. The first authentication information acquisition device 50 reads fingerprint information of the user as the first authentication information.

As still another example, the first authentication information may be recorded in an integrated circuit (IC) card or a magnetic card carried with the user. In this case, the first authentication information acquisition device 50 has a card reader (IC card reader or magnetic card reader). The first authentication information acquisition device 50 reads the first authentication information using the card reader.

The first authentication information acquisition device 50 is provided to be accessed from the outside of the autonomous driving vehicle 30. Typically, the first authentication information acquisition device 50 is provided on the outer surface of the autonomous driving vehicle 30. The first authentication information acquisition device 50 may be covered with a cover. Alternatively, in a case where the first authentication information acquisition device 50 is a communication device, the first authentication information acquisition device 50 does not need to be provided on the outer surface of the autonomous driving vehicle 30. As long as the first authentication information can be acquired from

the user outside the autonomous driving vehicle **30**, the position where the first authentication information acquisition device **50** is provided is optional.

The second authentication information acquisition device **60** acquires authentication information from the user inside the vehicle cabin of the autonomous driving vehicle **30**. In order to acquire the authentication information from the user inside the vehicle cabin of the autonomous driving vehicle **30**, the second authentication information acquisition device **60** is provided inside the autonomous driving vehicle **30**. The authentication information acquired by the second authentication information acquisition device **60** is used in the second authentication processing. The authentication information for use in the second authentication processing is hereinafter referred to as “second authentication information”.

For example, the second authentication information is provided to the user in a format of a QR code. In this case, the second authentication information acquisition device **60** has a QR code reader that reads the QR code. The user displays the QR code indicating the second authentication information on the display unit of the user terminal **10** and puts the display unit over the QR code reader. The second authentication information acquisition device **60** can acquire the second authentication information by reading the QR code.

As another example, the second authentication information may be a PIN code. In this case, the second authentication information acquisition device **60** has a communication device that performs communication with the user terminal **10**. The user transmits the PIN code using the user terminal **10** and requests for authentication. The second authentication information acquisition device **60** receives the second authentication information (PIN code) sent from the user terminal **10**. As a communication system in this case, a communication system (for example: Wi-Fi) in which an effective communication distance is limited to the inside of the autonomous driving vehicle **30** is used. This is to restrain the second authentication information from being received from the user outside the autonomous driving vehicle **30** in the second authentication processing.

The traveling device **70** includes a steering device, a drive device, and a braking device. The steering device steers wheels. The drive device is a power source that generates drive power. As the drive device, an electric motor or an engine is illustrated. The braking device generates braking force.

The HMI unit **80** is an interface that notifies the user of information and receives information from the user. For example, the HMI unit **80** includes a display device, a speaker, an input device, and a microphone. The HMI unit **80** can notify the user of various kinds of information through the display device or the speaker. As the input device, a touch panel, a switch, or a button is illustrated. The user can input various kinds of information to the HMI unit **80** using the input device or the microphone.

The door lock device **90** locks the door of the autonomous driving vehicle **30** or releases the door lock.

The control device **100** controls the autonomous driving vehicle **30**. In particular, the control device **100** controls the driverless transportation service with the autonomous driving vehicle **30**. For example, the control device **100** performs control such that the traveling device **70** controls traveling of the autonomous driving vehicle **30**. Typically, the control device **100** is a microcomputer including a

processor, a memory, and an input/output interface. The control device **100** is also referred to as an electronic control unit (ECU).

1-4. Departure Condition Confirmation Processing

When the autonomous driving vehicle **30** picks the user up, the control device **100** performs the departure condition confirmation processing for determining whether or not the departure condition is satisfied. As shown in FIG. 2, the departure condition is that authentication of the user is completed in both of the first authentication processing and the second authentication processing. The control device **100** prohibits the start of the autonomous driving vehicle **30** until the departure condition is satisfied. In a case where the departure condition is satisfied, the control device **100** permits the start of the autonomous driving vehicle **30**.

FIG. 4 is a flowchart showing the departure condition confirmation processing in the control device **100** of the autonomous driving vehicle **30** according to the first embodiment of the disclosure. Hereinafter, the departure condition confirmation processing according to the first embodiment of the disclosure will be described in detail.

1-4-1. User Information Acquisition Processing (Step S100)

The control device **100** acquires user information from the management server **20** through the communication device **40**. The user information is information relating to the user who is picked up by the autonomous driving vehicle **30**, and includes, for example, the pickup position desired by the user. The first authentication information for use in the first authentication processing is also included in the user information.

FIG. 5 shows an example of a distribution method of the first authentication information with the management server **20** according to the first embodiment of the disclosure. The user sends the vehicle allocation request to the management server **20** using the user terminal **10** (Step S111). The management server **20** generates the first authentication information associated with the user in response to the vehicle allocation request (Step S121). The management server **20** provides the generated first authentication information to the user terminal **10** and the autonomous driving vehicle **30** (Step S122). The control device **100** of the autonomous driving vehicle **30** receives the first authentication information from the management server **20** through the communication device **40** (Step S131). The user terminal **10** receives the first authentication information from the management server **20** (Step S112). For example, the first authentication information is provided to the user terminal **10** in a format of a QR code or a PIN code.

FIG. 6 shows another example of the distribution method of the first authentication information with the management server **20** according to the first embodiment of the disclosure. In the example shown in FIG. 6, at least a part of the registration information of the user registered in the management server **20** in advance is used as the first authentication information. For example, biological information (for example: fingerprint) of the user is registered as the registration information and is used as the first authentication information. Alternatively, membership information of the user may be used as the first authentication information.

In more detail, the user performs a user registration application using the user terminal **10** (Step S10). The management server **20** performs user registration processing

(Step S20). The registration information of the user is registered (stored) in the management server 20 in advance. Thereafter, the user sends the vehicle allocation request to the management server 20 using the user terminal 10 (Step S111). The management server 20 acquires at least a part of the registration information of the user as the first authentication information in response to the vehicle allocation request (Step S123). The management server 20 provides the acquired first authentication information to the autonomous driving vehicle 30 (Step S124). The control device 100 of the autonomous driving vehicle 30 receives the first authentication information from the management server 20 through the communication device 40 (Step S131). In the first embodiment of the disclosure, the first authentication information does not need to be provided from the management server 20 to the user terminal 10.

1-4-2. First Authentication Processing (Step S200)

In a case where the autonomous driving vehicle 30 arrives at the pickup position desired by the user, the control device 100 performs the first authentication processing. In the first authentication processing, the control device 100 performs authentication of the user outside the autonomous driving vehicle 30. For authentication, the control device 100 acquires the first authentication information from the user outside the autonomous driving vehicle 30 using the above-described first authentication information acquisition device 50.

For example, the user displays a QR code indicating the first authentication information on the display unit of the user terminal 10 and puts the display unit over the first authentication information acquisition device 50 (QR code reader). The first authentication information acquisition device 50 acquires the first authentication information by reading the QR code.

As another example, the user transmits a PIN code indicating the first authentication information using the user terminal 10. The first authentication information acquisition device 50 (communication device) receives the first authentication information (PIN code) sent from the user terminal 10.

In still another example, the first authentication information is a fingerprint of the user. In this case, the user puts the finger over the first authentication information acquisition device 50 (fingerprint reader). The first authentication information acquisition device 50 reads fingerprint information of the user as the first authentication information.

In still another example, the first authentication information is recorded in an IC card or a magnetic card carried with the user. The user makes the first authentication information acquisition device 50 (card reader) read the first authentication information recorded in the IC card or the magnetic card.

The control device 100 performs authentication of the user based on the first authentication information acquired from the management server 20 in Step S100 and the first authentication information acquired from the user using the first authentication information acquisition device 50. In a case where authentication of the user is successful, the first authentication processing is completed. In a case where the first authentication processing is completed, the process progresses to next Steps S300 and S400.

1-4-3. Door Lock Release Processing (Step S300)

The control device 100 performs door lock release processing in response to the completion of the first authentication processing.

Specifically, the control device 100 performs control such that the door lock device 90 releases the door lock of the autonomous driving vehicle 30. In a case where the door lock is released, the user gets in the autonomous driving vehicle 30.

1-4-4. Second Authentication Information Provision Processing (Step S400)

The control device 100 performs second authentication information provision processing in response to the completion of the first authentication processing. In the second authentication information provision processing, the control device 100 makes the user who sends the vehicle allocation request acquire the second authentication information for use in the second authentication processing. For example, the second authentication information is provided to the user terminal 10 in a format of a QR code or a PIN code.

FIG. 7 shows an example of the second authentication information provision processing (Step S400) according to the first embodiment of the disclosure. The control device 100 of the autonomous driving vehicle 30 generates the second authentication information (Step S431). The control device 100 provides the generated second authentication information to the user terminal 10 (Step S432). For example, the control device 100 transmits the second authentication information to the user terminal 10 using the communication device 40. Alternatively, the control device 100 may transmit the second authentication information to the management server 20 using the communication device 40, and the management server 20 may transfer the second authentication information to the user terminal 10. That is, the control device 100 may provide the second authentication information to the user terminal 10 through the management server 20. The user terminal 10 receives the second authentication information (Step S411).

FIG. 8 shows another example of the second authentication information provision processing (Step S400) according to the first embodiment of the disclosure. The control device 100 of the autonomous driving vehicle 30 sends a second authentication information generation request to the management server 20 using the communication device 40 (Step S433). The second authentication information generation request is information for requesting the management server 20 to generate and provide the second authentication information. The management server 20 generates the second authentication information in response to the second authentication information generation request (Step S421). The management server 20 provides the generated second authentication information to the user terminal 10 and the autonomous driving vehicle 30 (Step S422). The control device 100 of the autonomous driving vehicle 30 receives the second authentication information from the management server 20 through the communication device 40 (Step S434). The user terminal 10 receives the second authentication information from the management server 20 (Step S412).

In the first embodiment of the disclosure, the second authentication information for use in the second authentication processing is different from the first authentication information for use in the first authentication processing. In the specification, the term "different" means that types are different or the types are identical but contents are different.

The sequence of Steps S300 and S400 is optional. In a case where Steps S300 and S400 are completed, the process progresses to next Step S500.

1-4-5. Second Authentication Processing (Step S500)

The control device **100** performs the second authentication processing. In the second authentication processing, the control device **100** performs authentication of the user (that is, the user who gets in the autonomous driving vehicle **30**) inside the vehicle cabin of the autonomous driving vehicle **30**. In order to perform authentication of the user inside the vehicle cabin of the autonomous driving vehicle **30**, the control device **100** acquires the second authentication information from the user inside the vehicle cabin of the autonomous driving vehicle **30** using the above-described second authentication information acquisition device **60**.

For example, the user displays a QR code indicating the second authentication information on the display unit of the user terminal **10** and puts the display unit over the second authentication information acquisition device **60** (QR code reader). The second authentication information acquisition device **60** acquires the second authentication information by reading the QR code.

As another example, the user transmits a PIN code indicating the second authentication information using the user terminal **10**. The second authentication information acquisition device **60** (communication device) receives the second authentication information (PIN code) sent from the user terminal **10**.

The control device **100** performs authentication of the user based on the second authentication information generated or acquired in Step S400 and the second authentication information acquired from the user using the second authentication information acquisition device **60**. In a case where authentication of the user is successful, the second authentication processing is completed. In a case where the second authentication processing is completed, the process progresses to next Step S600.

1-4-6. Start Permission Processing (Step S600)

In a case where the second authentication processing is completed, the control device **100** permits the start of the autonomous driving vehicle **30**. In this case, the control device **100** may perform control such that the door lock device **90** automatically locks the door of the autonomous driving vehicle **30**. Thereafter, the control device **100** performs control such that the traveling device **70** starts the autonomous driving vehicle **30**. The autonomous driving vehicle **30** travels from the pickup position desired by the user toward the destination.

1-5. Effects

As described above, according to the first embodiment of the disclosure, in the departure condition confirmation processing, the two-stage authentication processing is performed. Specifically, the first authentication processing is performed to the user outside the autonomous driving vehicle **30** before the release of the door lock. After the completion of the first authentication processing, the second authentication information different from the first authentication information is provided to the user, and the second authentication processing is performed to the user inside the vehicle cabin of the autonomous driving vehicle **30**. In a case where the second authentication processing is completed, the start of the autonomous driving vehicle **30** is permitted.

With the first authentication processing before the release of the door lock, another person other than the user who transmits the vehicle allocation request is restrained from getting in the autonomous driving vehicle **30** arrived at the pickup position without permission. With the second authentication processing, the autonomous driving vehicle **30** is restrained from starting in a state in which the user does not get in the autonomous driving vehicle **30**. For example, the autonomous driving vehicle **30** is restrained from starting without permission while the user is loading a cargo in a trunk of the autonomous driving vehicle **30**.

With the two-stage authentication processing, the following effect is also obtained. For example, a case where another person who is malicious acquires the first authentication information of the user in an unauthorized manner with means, such as hacking, is considered. According to the first embodiment of the disclosure, after the completion of the first authentication processing, the second authentication information different from the first authentication information is provided to the authorized user, and the second authentication processing is performed based on the second authentication information. Accordingly, for example, even though another person can acquire the first authentication information, another person cannot pass the second authentication processing. That is, it is not possible for another person to start the autonomous driving vehicle **30**.

As described above, according to the first embodiment of the disclosure, it is possible to restrain the start of the autonomous driving vehicle **30** in a state in which the user who transmits the vehicle allocation request does not get in the autonomous driving vehicle **30**. That is, it is possible to restrain the start of the autonomous driving vehicle **30** unintended by the user. Accordingly, a sense of discomfort or inconvenience imposed on the user is reduced. This contributes to improvement of reliability to the autonomous driving vehicle **30** and the driverless transportation service.

2. Second Embodiment

In a second embodiment of the disclosure, the autonomous driving vehicle **30** prompts the user to perform an authentication operation (for example, put a QR code) for the second authentication processing as needed. Others are the same as those in the first embodiment. Description overlapping the first embodiment is appropriately omitted.

FIG. 9 is a flowchart showing second authentication processing (Step S500) according to the second embodiment of the disclosure. The control device **100** of the autonomous driving vehicle **30** determines whether or not the second authentication processing is completed (Step S510). In a case where the second authentication processing is completed (Step S510; Yes), Step S500 ends. In a case where the second authentication processing is not completed (Step S510; No), the process progresses to Step S520.

The control device **100** measures an elapsed time after the first authentication processing (Step S200) is completed. In Step S520, the control device **100** determines whether or not the elapsed time reaches predetermined time T1. In a case where the elapsed time does not reach predetermined time T1 (Step S520; No), the process returns to Step S510. In a case where the elapsed time reaches predetermined time T1 (Step S520; Yes), the process progresses to Step S530.

In Step S530, the control device **100** prompts the user to perform an authentication operation using the HMI unit **80**. For example, the control device **100** outputs voice guidance, "please make an authentication operation", using the speaker of the HMI unit **80**. The control device **100** may

display a message, “please make an authentication operation”, on the display device of the HMI unit **80**. The control device **100** may inform the user a method of an authentication operation. Thereafter, the process returns to Step **S510**.

As described above, according to the second embodiment of the disclosure, after the completion of the first authentication processing, in a case where the second authentication processing is not completed even when predetermined time **T1** elapses, the execution of the authentication operation is prompted. With this, the autonomous driving vehicle **30** does not stay at the pickup position for a long time needlessly and is expected to start early. This results in reduction (improvement of a turnover rate) of a time on duty of the autonomous driving vehicle **30**, and is preferable for a provider who provides the driverless transportation service.

3. Third Embodiment

A third embodiment of the disclosure is a modification of the second embodiment. Description overlapping the first embodiment and the second embodiment is appropriately omitted.

FIG. **10** is a flowchart showing second authentication processing (Step **S500**) according to the third embodiment of the disclosure. Steps **S510** to **S530** are the same as those in the second embodiment. After Step **S530**, the process progresses to Step **S540**.

In Step **S540**, the control device **100** determines whether or not the elapsed time after the completion of the first authentication processing reaches predetermined time **T2**. Predetermined time **T2** is longer than predetermined time **T1**. In a case where the elapsed time does not reach predetermined time **T2** (Step **S540**; No), the process returns to Step **S510**. In a case where the elapsed time reaches predetermined time **T2** (Step **S540**; Yes), the control device **100** starts charging to the user authenticated by the first authentication processing (Step **S550**). Thereafter, the processing flow shown in FIG. **9** is continued.

Before charging starts, the control device **100** may notify the user that “charging starts” using the HMI unit **80**.

In determination about whether or not to start charging, the supply and demand of the autonomous driving vehicle **30** may be taken into consideration. For example, charging may start solely when demand exceeds supply. The autonomous driving vehicle **30** acquires information relating to supply and demand from the management server **20**. The management server **20** can predict supply and demand from a past trend or the like.

A condition for starting charging may be determined based on the number of vehicles, the number of vehicles that can be currently allocated, a route plane of a vehicle that is currently traveling, a destination arrival time, or the like.

As described above, according to the third embodiment of the disclosure, after the completion of the first authentication processing, in a case where the second authentication processing is not completed even when predetermined time **T2** elapses, charging to the user starts. Accordingly, an effect of reduction (improvement of a turnover rate) of the time on duty of the autonomous driving vehicle **30** is expected to be further enhanced. This is preferable for a provider who provides a driverless transportation service.

Although the embodiment of the disclosure has been described above in detail, the disclosure is not limited to the above-described embodiment, and various modifications or alterations may be made without departing from the spirit and scope of the disclosure described in the claims.

What is claimed is:

1. An autonomous driving vehicle that provides a driverless transportation service to a user, the autonomous driving vehicle comprising one or more processors configured to:
 - 5 acquire first authentication information associated with the user from the user outside the autonomous driving vehicle;
 - generate second authentication information associated with the user; and
 - 10 control the autonomous driving vehicle, wherein the one or more processors are further configured to perform, in response to the autonomous driving vehicle picking up the user, departure condition confirmation processing, wherein the departure condition confirmation processing comprises:
 - 15 authenticating the user outside the autonomous driving vehicle based on the first authentication information, releasing a door lock of the autonomous driving vehicle in response to authenticating the user outside the autonomous driving vehicle,
 - controlling transmission of the second authentication information to a user terminal based on the user entering the vehicle cabin of the autonomous driving vehicle,
 - 20 subsequent to authenticating the user outside the autonomous driving vehicle, authenticating the user inside the vehicle cabin of the autonomous driving vehicle based on the second authentication information, and
 - 25 permitting a start of the autonomous driving vehicle in response to authenticating the user inside the vehicle cabin.
2. The autonomous driving vehicle according to claim 1, wherein the one or more processors are further configured to prompt the user to perform second authentication operation.
3. The autonomous driving vehicle according to claim 1, wherein the one or more processors are configured to prompt the user to perform second authentication operation when authenticating the user inside the vehicle cabin is not completed after a predetermined time lapses and authenticating the user outside the autonomous driving vehicle is completed.
4. The autonomous driving vehicle according to claim 1, wherein subsequent to authenticating the user outside the autonomous driving vehicle, and in response to an incomplete authentication of the user inside the vehicle cabin after a first predetermined time elapses, the one or more processors are further configured to prompt the user to perform authentication inside the vehicle cabin.
5. The autonomous driving vehicle according to claim 4, wherein subsequent to authenticating the user outside the autonomous driving vehicle, and in response to an incomplete authentication of the user inside the vehicle cabin after a second predetermined time longer than the first predetermined time elapses, the one or more processors are further configured to charge the user authenticated outside the autonomous driving vehicle.
6. The autonomous driving vehicle of claim 1, wherein the first authentication information is registration information of the user that is registered in advance.
7. The autonomous driving vehicle of claim 1, wherein the first authentication information is different from the second authentication information.
8. The autonomous driving vehicle of claim 1, wherein subsequent to authenticating the user outside the autonomous driving vehicle and prior to releasing the door lock of the autonomous driving vehicle, the one or more processors

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are further configured to restrict entry of an unauthenticated user into the autonomous driving vehicle.

9. A driverless transportation system that provides a driverless transportation service to a user, the driverless transportation system comprising:

- a management server; and
- an autonomous driving vehicle configured to be able to communicate with the management server, wherein: the autonomous driving vehicle comprises one or more processors configured to:
 - acquire first authentication information associated with the user from the user outside the autonomous driving vehicle; and
 - generate second authentication information associated with the user; and
- perform departure condition confirmation processing in response to the autonomous driving vehicle picking the user up, wherein the departure condition confirmation processing comprises:
 - authenticating the user outside the autonomous driving vehicle based on the first authentication information,
 - releasing a door lock of the autonomous driving vehicle in response to authenticating the user outside the autonomous driving vehicle,
 - controlling transmission of the second authentication information to a user terminal based on the user entering the vehicle cabin of the autonomous driving vehicle,
 - authenticating the user inside the vehicle cabin of the autonomous driving vehicle based on the second authentication information, and
 - permitting a start of the autonomous driving vehicle in response to authenticating the user inside the vehicle cabin of the autonomous driving vehicle.

10. The driverless transportation system according to claim 9, wherein the one or more processors are further configured to prompt the user to perform second authentication operation.

11. The driverless transportation system according to claim 9, wherein the one or more processors are configured to prompt the user to perform second authentication operation when authenticating the user inside the vehicle cabin is not completed after a predetermined time lapses and authenticating the user outside the autonomous driving vehicle is completed.

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12. The driverless transportation system according to claim 9, wherein the management server is configured to: generate the first authentication information; and transmit the generated first authentication information to the autonomous driving vehicle and the terminal of the user in response to a vehicle allocation request from the user.

13. The driverless transportation system according to claim 9, wherein the first authentication information is registration information of the user that is registered in the management server in advance, and wherein the management server is configured to provide the registration information as the first authentication information to the autonomous driving vehicle in response to a vehicle allocation request from the user.

14. A method for providing a driverless transportation service to a user, the method being executed by at least one processor, the method comprising:

- acquiring first authentication information associated with the user from the user outside an autonomous driving vehicle;
 - generating second authentication information associated with the user; and
- in response to the autonomous driving vehicle picking up the user, performing departure condition confirmation processing, wherein the departure condition confirmation processing comprises:
- authenticating the user outside the autonomous driving vehicle based on the first authentication information;
 - releasing a door lock of the autonomous driving vehicle in response to authenticating the user outside the autonomous driving vehicle;
 - controlling transmission of the second authentication information to a user terminal based on the user entering the vehicle cabin of the autonomous driving vehicle;
 - subsequent to authenticating the user outside the autonomous driving vehicle, authenticating the user inside the vehicle cabin of the autonomous driving vehicle based on the second authentication information, and
 - permitting a start of the autonomous driving vehicle in response to authenticating the user inside the vehicle cabin.

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